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Difference in Activity Corresponding to Changing Water Temperature among Juvenile Green Sea Turtles

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ABSTRACT

In this study, a tank experiment was conducted to investigate the change in the activity level of juvenile green turtles reared for three months when exposed to water at a range of temperatures (13 to 25 ^{o}C). The results of the experiment show that the activity level of juvenile green turtles declined with lower water temperature. Moreover, in cold waters at temperatures of 13-15 ^{o}C, unusual swimming activity was observed. For example, the frequency of stroking was not constant, or the timing of stroking with both flippers did not coincide. These results indicate that staying in cold waters for a long period would be critical for juvenile green turtles.

Keywords: *Chelonia mydas*, behavioral response, cold stun, response to changing water temperature

INTRODUCTION

Sea turtle hatchlings after emerge from their nests crawl to the beach, and then disperse to open ocean (Lohmann et al. 1997). In the open ocean, since it is quite difficult to find small hatchlings, little is known about the behavior and ecology of post-hatchlings and juvenile sea turtles. Therefore, this stage of life history is called "lost years" (Carr and Meylan 1980). Sea turtles in "lost years" are assumed to be drifting by ocean currents (Musick and Limpus 1997). To add the knowledge of their ecology during this stage, in this study, we conducted the tank experiment to investigate the activity of juvenile green turtles born at Ishigaki Island, Japan in response to a wide range of water temperature, because if they undertake trans-Pacific migration by passive drifting on the Kuroshio and Kuroshio-extension currents, they would experience lowest water temperature of around 10 ^{o}C (Okuyama et al. 2010).

MATERIALS AND METHODS

Study field

All experiments were conducted at the Yaeyama Station, Seikai National Fisheries Research Institute, Fisheries Research Agency, Japan which is located in Ishigaki Island, southwestern part of Japan. Ishigaki Island has several nesting sites of loggerhead (*Caretta caretta*), green (*Chelonia mydas*) and hawksbill turtles (*Eretmochelys imbricata*) (Abe et al. 2003). Also, there are some feeding aggregations of immature green and hawksbill turtles in the waters around Ishigaki island (Okuyama et al. 2010, Okuyama et al. 2013).

Experimental animals

Green turtle hatchlings were collected from nests on the beaches of Ishigaki Island, (24ºN, 124ºE) Okinawa-prefecture, Japan. We conducted beach patrols and when we found nesting green turtles, the date and location of were recorded. According to the date of nesting, we predicted the date of hatchling emergence from the nests. A few hours before the hatchlings emerge naturally in the night, we dug up the eggs and captured three or four hatchlings from each nest. In total, 14 hatchlings were collected. The hatchlings were immediately placed into tanks at the Yaeyama Station, and then settled in the rearing tanks which was filled with sea water pumped from coastal waters. All of the 14 hatchlings were raised for three months at a water temperature of 25-28 ^{o}C for the experiments. Body size and weight of turtles were measured before experiments. Their straight carapace lengths (SCL), straight carapace width (SCW) and body weight (BW) are summarized in Table 1. After the experiments, all turtles were released on the beach.

Table 1. Physical data of the experiment turtles.

ID	SCL (mm)	SCW (mm)	BW (g)
1	105.9	90.2	197
2	113.9	98.7	215
3	112.6	93.6	223
4	112.3	98.2	207
5	113.5	96.0	219
6	109.0	92.2	207
7	112.9	92.6	212
8	115.2	98.1	229
9	109.8	94.7	200
10	118.0	98.9	222
11	116.4	96.3	235
12	110.1	91.2	225
13	112.4	96.0	223
14	108.0	90.4	297

Experimental procedure

The experiments were conducted during 0900 to 1600 on 14 November to 2 December 2011. The turtles were placed in a square tank (Length × Width × Height: 105 cm × 105 cm × 90 cm) and we acclimated them to 28 ºC water. The tank was filled with the sea water at a depth of about 30 cm and connected with a thermo-regulator. Then, we recorded the activity level in the tank when turtles were exposed to the water at various temperatures (13, 15, 18, 20, 23 and 25 ˚C) every 30 minutes. Here, we defined the the activity level as the number of strokes. The number of strokes was counted by video observation and we divided the number by 30. Considering the effect of elapsed time, we changed the water temperature in two patterns shown in Figure 1.

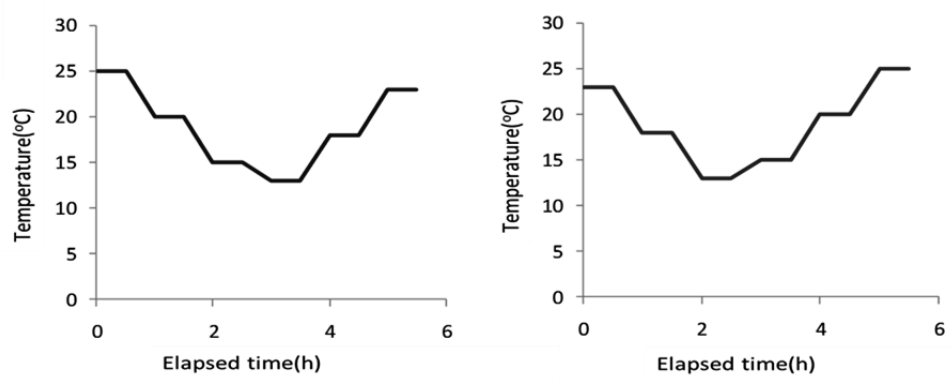

Figure 1 Changes in water temperature during the experiment

RESULTS

The number of strokes per minute decreased with lower temperature, and the declined was particularly sharp at the temperatures 13 ºC and 15 ºC (Fig. 2). However, the number of strokes recovered when water temperature was above 15 ºC again. This trend was observed in all individuals.

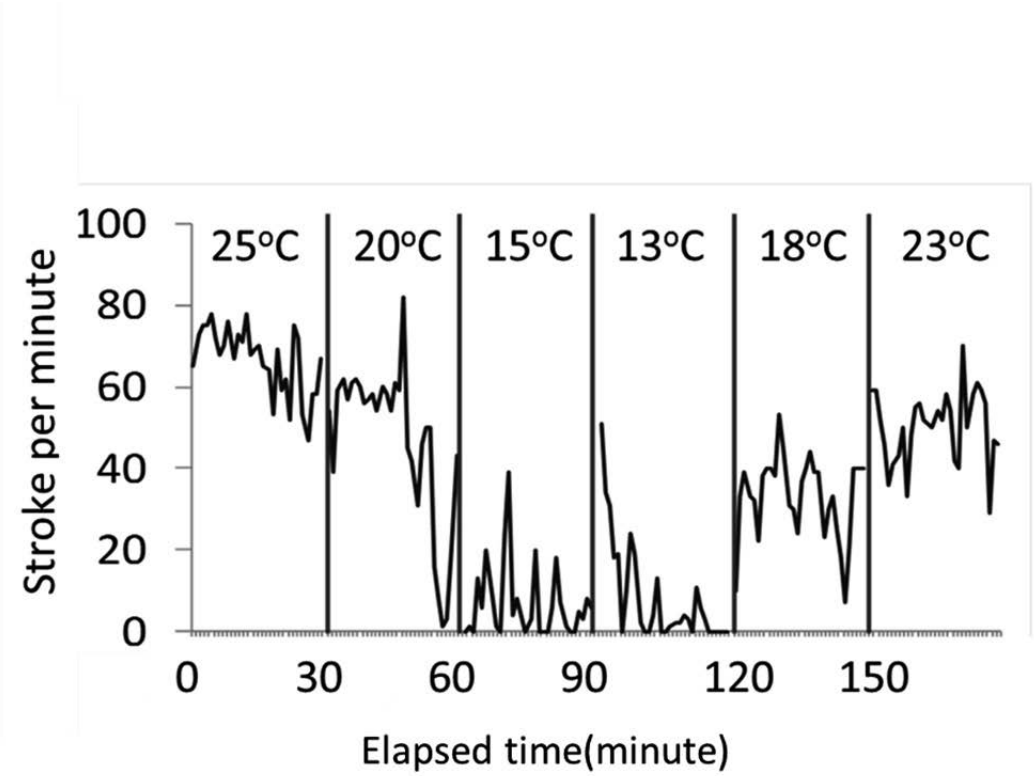

Figure 2 Typical example of the transition of the number of strokes per minute in response to the various temperatures (25 ºC, 20 ºC, 15 ºC, 13 ºC, 18 ºC and 23 ºC). The turtles were exposed to each temperature at an interval of 30 minutes.

We summarize the changes in the number of strokes in response to water temperature in Figure 3. The number of strokes was highest at a temperature of 25 ºC, and decreased with lower temperatures. There was a significant difference in the number of strokes between the water temperatures below 15 ºC and 25 ºC ($P < 0.05$, ANOVA and post-hoc Bonferroni tests). Visual observation of the turtle behavior found that erratic swimming activity and slower movement were observed at the temperatures of 13 ºC and 15 ºC. For example, the frequency of stroking was not constant, or the timing of stroking by both flippers did not coincide.

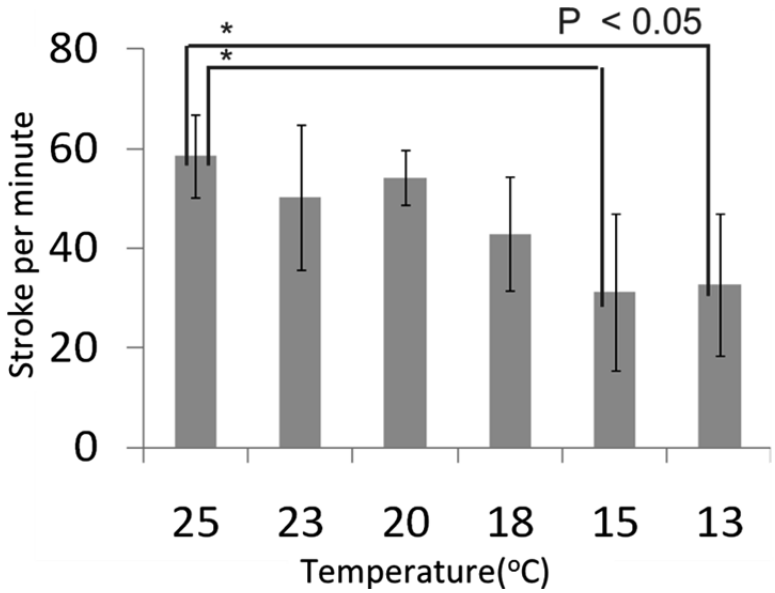

Figure 3 Changes in activity level at different temperatures among juvenile green turtles. The black bars represent standard error.

DISCUSSION

In this experiment, we quantitatively evaluated the change in the activity level of juvenile green turtles in the water at different temperatures. The results of our study indicate that activity of turtles declined with lower water temperature, although the fatigue resulting from continuous swimming may cause the decrement in activity level, because the decline in activity was mostly occurred around two hours after the onset of experiment. The previous study reported that green turtle hatchling got floated at 9 ºC, and temperatures 5 to 6 ºC were the a lethal lower limit (Schwarts, 1978), although the upper limit has not yet been investigated. Moreover, when juvenile green turtles stay in cold areas (below 8 ºC) for a long time, they would die from cold stun (Witherington and Ehrhart, 1989). These facts and our results indicate that, as water temperature approaches the lower lethal temperature, the activity level of turtles decreases, and then the turtles may show erratic behavior or cold stun, particularly at the water temperatures below 15 ºC. Moreover, our results imply that juvenile green turtles might be in low activity level and consequently drift on ocean currents when they encounter cold waters, or the may try to escape from cold water to avoid a decrease in activity level.

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